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AN EVALUATION OF FOREST INSECT AND DISEASE RESEARCH NEEDS IN OREGON AND WASHINGTON

PART II DISEASES

By

Northwest Forest Pest Action Committee

November, 1953

BUREAU OF
Entomology and Plant Quarantine
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Associated Forest Industries of Oregon

Bureau of Entomology and Plant Quarantine

Bureau of Land Management

Bureau of Plant Industry Soils and Agricultural Engineering

United States Forest Service

United States Indian Service

Industrial Forestry Association

Keep Oregon Green Association

Keep Washington Green Association

Oregon Extension Service

Oregon Forest Fire Association

Oregon State Board of Forestry

Oregon State College

Soil Conservation Service

Southern Oregon Conservation and Tree Farm Association

State College of Washington

Tree Farm Management Service

University of Washington

Washington Forest Fire Association

Washington State Division of Forestry

Washington Forest Industries Association

Western Forestry and Conservation Association

Western Pine Association

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TABLE OF CONTENTS

	Page Number
SUMMARY AND RECOMMENDATIONS	1
Summary of the Forest Disease Problem with Respect to Pathology Research	1
Summary of Recommendations	3
GENERAL FOREST DISEASE RESEARCH PROBLEMS	5
Forest Disease Surveys	5
Forest Practices in Relation to Disease Development	8
Salvage and Utilization Aspects of Forest Disease	9
SPECIFIC DISEASE PROBLEMS	12
Diseases Requiring Immediate Investigation	12
Poria Weirii Root Rot of Douglas Fir	12
Cinnamon Root Rot and Port Orford Cedar Root Rot Caused by *Phytophthora* spp.	14
Needle Blight of Ponderosa Pine	18
White Pine Blister Rust	20
Forest Nursery Diseases	22
Diseases Needing Prompt Investigation	23
Mistletoe on Ponderosa Pine	23
Decay in Second Growth Stands of Important Timber Species	26
Root and Butt Rot of Western Hemlock, Ponderosa Pine, and Other Important Commercial Species	26
Important Diseases Where Attention is Less Urgent	27

TABLE OF CONTENTS

	Page Number
Mistletoe on Western Hemlock, Douglas Fir, and Larch	27
Diseases in Forest Plantations.	27
ASSESSMENT OF PRESENT RESEARCH EFFORT	28
BIBLIOGRAPHY.	30

F O R E W O R D

The Northwest Forest Pest Action Committee has become increasingly alarmed over the destruction caused by insects and diseases in the forests of the Pacific Northwest. While less spectacular than forest fires, insects and diseases take a terrific toll in our forests. Timber killed annually by insects and disease amounts to about 1/5 of the yearly log production in Oregon and Washington--two states where the forest industries are primary in their contribution to employment, regional income and economic stability.

The Northwest Forest Pest Action Committee has taken leadership in promoting the control of destructive forest insects in the region, such as the spruce budworm, the Douglas fir beetle, the western pine beetle, and others. Realizing, that more information is needed to understand the behavior and control of insects and diseases, the committee established on December 11, 1952 an Insect and Disease Research Sub-committee. At its first meeting the Research Sub-committee defined its responsibilities as follows:

(1) To evaluate the need for research on forest insects and diseases in Oregon and Washington.

(2) To determine the extent and quality of insect and disease research of the various public and private organizations.

(3) To recommend and promote research programs in the two states in order that a coordinated, objective, agressive and comprehensive approach to solving our

insect and disease problems be developed as rapidly as possible.

(4) To stimulate the dissemination of insect and disease research information to the various public and private organizations.

In an effort to meet these objectives, the Insect and Disease Research Sub-committee has prepared the following report. The report is divided into two parts--Part I, Insects, and Part II, Diseases, with a summary and recommendations appearing at the beginning of each part. The sub-committee believes that its report represents the best evaluation of the current needs for research on forest insects and diseases now available. Further, it believes that the fulfillment of its recommendations will result in a more realistic and effective approach to solving Northwest insect and disease problems.

SUMMARY AND RECOMMENDATIONS

Summary of the Forest Disease Problem with Respect to Pathology Research

There is no accurate method at the present time of estimating the drain due to forest disease in the ponderosa pine and Douglas fir regions of Oregon and Washington. In a few instances, reasonably accurate figures are available. In old growth Douglas fir, for example, there is known to exist a cumulative decay mass exceeding 50 billion board feet. On the other hand, there are diseases of unquestioned importance for which we have no figures, and other destructive diseases are probably being overlooked. The estimated annual loss of 250 million board feet of second growth Douglas fir caused by Poria weirii Murr. which went largely unobserved until 1946, is an example of the latter.

Currently available forest disease loss information applies almost exclusively to timber of merchantable size. There are few figures relating to stands of the younger age classes, yet sometimes young stands may be so generally infected as to be almost worthless. Such stands have no future of their own and constitute a menace to surrounding healthy timber. Examples of this condition are found in both dwarf mistletoe and needle blight of ponderosa pine.

Lack of knowledge of current losses is a major factor restricting development of an adequate program of forest protection against disease. When losses cannot be clearly defined, forest management frequently is uninformed and unconcerned, the

general public remains indifferent, and losses continue unabated. Only in the case of conspicuous or impending epidemics have we been able to obtain concerted action against forest disease. It will probably one day be found true with forest diseases as with diseases of other crops that losses from conspicuous, severe outbreaks are far exceeded by losses from less conspicuous but consistently injurious diseases.

In this respect a fundamental difference exists between disease and fire as the cause of forest losses. Fire affects only a small portion of the total forest area. Fires are intermittent, widely scattered and usually cause well defined damage which can be assessed with reasonable accuracy. Disease damage on the other hand is usually intangible, poorly defined, and to a greater of lesser degree affects all of the forested area of the region all of the time.

The present report considers 13 forest diseases or groups of diseases which are sufficiently destructive to call for control. Eleven of these are native diseases and some are currently or potentially epidemic. However, control cannot progress satisfactorily until we can provide control agencies and forest managers with a broader basis of knowledge of disease occurrence and behavior than is now available. Much of this knowledge may be obtained only through well-planned research.

At the present time, the Division of Forest Pathology is the only agency doing a significant amount of research on forest disease problems of this region. Small contributions are being made by the State Board of Forestry, Oregon State College, and the Pacific Northwest Forest and Range Experiment Station.

The Office of Blister Rust Control proposes to initiate work on its immediate problems in 1954. This total effort represents four to five man-years annually.

The Division of Forest Pathology (10) 1/ lists 22 diseases requiring investigation in the near future. Some work has been done on 9 of these diseases, but none has been adequately studied. The minimum program of this Division adequate to present needs is estimated to require 9½ man-years annually for detailed research on the 10 most urgent diseases, and for less intensive work on other disease problems.

Research in forest pathology within the region is restricted first and foremost by inadequate financial support, second by insufficient personnel and third by inadequate facilities. If the needed funds were suddenly made available, the shortage of trained personnel would become very acute.

Summary of Recommendations

The committee recommends:

1. That increased funds be sought to support research on forest diseases by both public and private agencies; such funds to be obtained at a gradual rate of increase that will enable efficient expansion of the program and will insure continuity of the research.

1/ Numbers in parenthesis refer to the Bibliography.

2. That continued strengthening of the program of the Portland office of the Division of Forest Pathology be solicited.

3. That the research facilities of the state colleges and universities be enlisted to a greater degree for solution of forest disease problems.

   a. That technically trained staff members be relieved of part of their instructional duties to direct contract research on forest diseases.

   b. That funds be made available for hiring graduate student assistants, thus accomplishing the double purpose of purchasing high quality research at a minimum cost and at the same time training additional competent workers.

4. That a program be developed to assist timber owners and operators in assessing their disease losses, and that these losses be reported and the figures compiled by an appropriate agency where they may become generally useful.

5. That timber owners and managers be encouraged to assist pathology research by observing and recording disease conditions and their progress on forest lands under their jurisdiction, using their own personnel. This work will demand foresters with a reasonable knowledge of pathology. At present, training in pathology at some schools is

insufficient to enable graduates to conduct the above observations effectively. Strengthening of the instructional program is recommended.

6. That a broader program of permanent plot sampling of disease development be established to augment our deficient knowledge of current disease losses.

7. That wherever appropriate pathology investigations are in progress emphasis be placed on clarification of the effect of forest practices on disease occurrence.

Recommendations concerning specific diseases are to be found in this report along with discussion of the diseases.

GENERAL FOREST DISEASE RESEARCH PROBLEMS

RESEARCH TO IMPROVE FOREST DISEASE SURVEYS

It is axiomatic that the purpose of any survey should be the gathering of facts which will serve as the basis for decision and action.

Ideally, the facts revealed by a disease survey should (1) Fix boundaries and intensities of disease development; (2) Reveal environmental features attending disease occurrence, and (3) Express current and cumulative disease losses in terms of lessened earning power of forest lands, or losses in timber investment.

Frequently the survey accomplishes only the first of these objectives. The second is so greatly dependent on the skill of trained technical observers that it often fails of

accomplishment for want of skilled personnel. With respect to the third, only in the case of a few diseases have present survey methods effectively evaluated current losses. In the case of white pine blister rust, for example, current mortality can be analyzed rather accurately, though even then loss in productivity by stunting, deformation, etc., remains undetermined. Cumulative losses are partially reflected in cruises of heart rots in timber stands; however, losses which preceded those found at the time of inventory are usually purely conjectural. Early losses may actually have been greater than those found in the inventory (5).

Because of the diverse character of the diseases involved, no one technique of surveying losses is applicable to all situations. One generally familiar procedure is that of estimating decay defect in cruising or scaling. Another is the estimating of the threat of white pine blister rust, through cruising and mapping timber and ribes populations. In the course of the blowdown bark beetle survey of 1952 (22), the ground crews attempted to evaluate the contribution of diseases in predisposing stands to windthrow and windbreakage. The techniques of conducting each of the surveys cited were adapted to the nature of specific diseases inventoried, and, therefore, were radically different in each case. It will profit less to attempt a complete exploration of the survey methods in use, than to point out the most obvious deficiencies which exist at present.

In 1918, J. R. Weir (30), stated "There has always been a serious need for some method by which a fairly accurate estimate

can be made of the rate of decay of a stand of timber". Weir argues strongly the necessity of measuring disease losses on a permanent sample plot basis. Such plots, when measured intensively by trained pathologists, can approach the complete picture of losses so urgently needed by forest managers. At present there appears to exist no such region-wide program of inventorying disease losses.

While a system of permanent plots appears to be the most certain method of determining current losses, it has the disadvantages 1. of not applying to all diseases or all stages of a particular disease, 2. of becoming over-burdensome if it is to cover a wide range of timber types, sites and diseases, 3. of requiring too much time to get results when epidemic disease is concerned, and 4. of providing inadequate information on boundary and area relationships essential to control. With many diseases it will continue to be necessary to conduct surveys by means other than permanent sample plots. Nevertheless, the permanent plot promises so much for clarifying the question of current losses that it is here recommened that earnest consideration be given to development of such a program.

Another distinct aid in determining the existence and extent of disease outbreaks is the vigilance of foresters, timber cruisers and other woods workers. Their observations have been most helpful in the past and would be even more effective in the future if every trained man working in timberlands were familiar with the diseases in his locality and were aware of the importance of disease and of his service in reporting outbreaks to

responsible agencies.

Administrators should, wherever practicable, keep detailed records of disease conditions on their timberlands. This information is just as necessary as growth data in determining current and potential yield and in managing for maximum protection.

FOREST PRACTICES IN RELATION TO DISEASE DEVELOPMENT

It is apparent that in many instances forest and logging practices in current use bring about an increase in forest disease losses at a rate exceeding natural disease development. The known ways in which practices intensify disease losses are too numerous to enumerate in this report, and it is quite possible that the unknown effects will exceed the known. Forest practices contributing to increased disease exert a direct influence, as for example: 1. fire control, which enables unrestricted spread of such pests as the dwarf mistletoes; or 2. selective logging that alters stand quality or composition with attendant upset of the biological balance which may lead to disease; or 3. logging practices which cause injuries that facilitate infection. Forest practices also may have an indirect effect on forest disease brought about by site deterioration. Stands on deteriorated sites frequently suffer from a variety of physiological disorders or non-parasitic diseases. Pathogenic diseases also increase among trees growing on depleted sites.

An understanding of the effect of forest practices on disease is especially important inasmuch as improper practices, almost alone among the many factors contributing to forest

disease, lend themselves readily to modification or correction and hence to disease control.

Forest practices as they relate to disease incidence constitute one aspect of disease epidemiology. A thorough understanding of all possible factors that contribute to disease development is fundamental to control. Epidemiology constitutes a field of disease knowledge in which forest pathology is conspicuously weak. This lack of information is a primary contributor to the generally prevalent but erroneous attitude that forest disease cannot be controlled.

SALVAGE AND UTILIZATION ASPECTS OF FOREST DISEASE

From the research standpoint, salvage and utilization of killed or windthrown timber, and of timber already partly destroyed by decay or other agencies, present two distinct considerations. The first of these involves the development of techniques and products which will assure economically sound use of defective wood, thus underwriting salvage; it calls for methods of preventing further deterioration and for avoiding spread of infection to clean materials during storage, manufacture, and use. These problems are rightly problems of products pathology. They will not be discussed here in greater detail. The second consideration calls for minimizing deterioration during the interval between intial damage and salvage. An important phase of this problem involves the actual rate of deterioration and its relationship to loss.

Deterioration studies of windthrown timber in this region were prompted by the Olympic blowdown of 1921 (3, 6). The data

from these studies by the Division of Forestry Pathology are useful, but have certain drawbacks. First, they are based on merchantable volume at the time of study, so that many logs merchantable by present day standards were culled. Second, the climatic and ground conditions of the west side of the Olympic Peninsula are not typical of the Douglas fir region. A report now being prepared for publication by the Division of Forest Pathology will summarize data from the Olympic blowdown study and from more recent studies in the Necanicum, Detroit, and Quilcene areas. The recent studies indicate that the rate of deterioration of windthown timber varies directly with the mean annual temperature.

Until the present Douglas fir beetle epidemic there has been no pressing need for research in the deterioration of beetle-killed timber. Past outbreaks have been minor in relation to the present one. For example, the 1938-39 outbreak affected only approximately 10 to 15 per cent as much timber as the current epidemic. Where possible, the Division of Forest Pathology plans to pick out beetle-killed trees of the 1938-39 outbreak for use as a basis to determine the cumulative deterioration of beetle-killed timber over the 14- to 15-year period. A recent study (31) was made in the Millicoma area of Coos County, Oregon.

No data are available at present regarding the rate of deterioration of disease-killed timber in this region, as for example, ponderosa pine killed by needle blight or Douglas fir destroyed by root rot; however, the Poria weirii

root rot investigations now in progress (9) in the Division of Forest Pathology calls for study of the deterioration rate of killed trees.

Additional studies are needed with respect to trees killed by all causes. With respect to windthrow, information is needed on rate of deterioration in parts of the region warmer and drier than the Olympic Peninsula. Basic information concerning the effects of temperature and moisture would enable estimates of the approximate deterioration rate for any general area for which climatic data were available. Similarly, the Millicoma data (31) on deterioration of beetle-killed timber may not be typical of the region, as preliminary investigations in the Gifford Pinchot National Forest indicate a much faster rate of deterioration there. The Division of Forest Pathology proposes to place one or two men for several weeks each year on estimation of the rate of deterioration of beetle-killed timber.

Study of volume losses of this sort is not complicated, and it is possible for industry and public forest agencies to supplement such studies. Very little work is now in prospect on disease-killed timber.

Definite instances are know of interrelationship between disease, windthrow, and insect infestation. In other cases, relationships are suspected. The whole matter of disease as a factor contributing to windthow and insect attack needs investigation. Some information on this question has accumulated as a by-product of studies of factors contributing to windthrow, and investigation of Poria weirii root rot as well as earlier studies on butt and root rots of old growth timber.

In many instances, even though the rate of deterioration has been reasonably well known, salvage has been delayed undesirably long or has been impossible because of such physical or economic obstacles as remoteness and high cost of road construction. Salvage has invariably been a negative procedure with the destructive agent and prevailing economic conditions determining the time, place, and practicability of salvage. Salvage must inevitably become a part of forest planning. Research on epidemiology of critical diseases would help delimit areas of high hazard and would enable salvage planning in advance of loss as an integral part of the overall management plan.

SPECIFIC FOREST DISEASE PROBLEMS

DISEASES REQUIRING IMMEDIATE INVESTIGATION

PORIA WEIRII ROOT ROT OF DOUGLAS FIR

Research to date

Canadian workers were first to notice the destructiveness of this disease and for some time they did productive work on it. Their activities seem to have stopped with discontinuance of the work of Dr. Don Buckland (2, 18). However, it is anticipated that more work will be done in Canada.

The Division of Forest Pathology (7, 8) has established approximately 160 acres of permanent plots in which they have attempted to reconstruct the stand, and on which data are being obtained on annual loss, rate of spread, and effect of stand and site factors. A survey is in progress (9) to determine the location and extent of the disease. This survey is in its early

stages, but it is anticipated that on the basis of available personnel and funds, satisfactory techniques will be developed, and considerable information obtained within the next three or four years. Mr. J. W. Clark and Mr. J. A. Staley are studying the causal fungus.

Urgency of the Problem

We have no adequate data on the seriousness of this disease. Dr. T. W. Childs, of the Division of Forest Pathology, estimates that Poria weirii is reducing the productivity of our second growth Douglas fir stands by about 5 per cent, which is to say that we are now losing the production that might be obtained from an area of approximately one-half million acres. The intensive management to which our Douglas fir forest will be subjected in the future is expected to result in an increasing severity of attack by Poria weirii unless we can develop counter measures. Probably this increase will not be very rapid, but it seems only reasonable to get a good start on controlling the disease before the disease gets a better start on cutting down our forest production.

At present, there appears no chance of actual control in the near future. For a great many years to come, the results of local studies will be used principally in organizing salvage operations for maximum effectiveness. Control methods probably can be developed for any disease, if sufficient effort is made, and the sooner we accumulate a mass of information concerning this pest, the sooner we will be in a position to reduce its inroads. A complete knowledge of the principal features of the life history of the parasite in Douglas fir stands is

indispensable. Conditions under which new areas of infection originate, details of the method of spread from one tree to another, occurrence and effect of hyper-parasites, the extent to which spores spread the disease, the possibility that some Douglas firs may be congenitally resistant--all these and many other details are of great practical concern because of their bearing on control. More fundamental work, for example, cytological and physioligical studies of the fungus is also needed.

Participants

It is hoped that the Canadian workers will be able to continue on this disease, and it is expected that much will be done by the Portland office of the Division of Forest Pathology, principally along the lines already indicated. The disease would supply thesis material for several graduate students. Since the disease occurs on the two school forests of the University of Washington, that institution may be able to contribute to the project.

Excellent cooperation is being extended by some of the larger timber companies: for example, Weyerhaeuser, Port Blakely, and Crown Zellerbach. Some of these companies are themselves accumulating information from permanent plot studies.

CINNAMON ROOT ROT AND PORT ORFORD CEDAR ROOT ROT

Research to Date

1. Two species of Phytophthora cause killing disease of Northwest commercial conifers. P. lateralis Tucker and

Milbrath (17) appears restricted to Port Orford white cedar of which all varieties tested are susceptible (25). P. cinnamomi Rands, on the other hand, has a wide host range including Douglas fir, young trees of which are very susceptible (24). Symptoms of the two fungi on Chamaecyparis are indistinguishable.

2. Origin of P. lateralis is unknown. Since its first record in the Willamette Valley in the late 1930's (17), it has been observed scattered throughout the length of the main valley and also in Coos County. Several infections at Coos Bay are in naturally established seedlings. The disease is a major cause of economic loss in commercial nurseries of Oregon and has destroyed many windbreak, hedge, and specimen plantings.

3. Phytophthora cinnamomi was observed near Portland in 1948 and was discovered in a nursery in the Portland area in 1950 and subsequently in three other locations in the Willamette Valley (24). Its present distribution appears limited only by its recent introduction.

4. Both fungi are true soil inhabitants. They produce no above-ground spores, hence their spread is dependent on growth through the soil and movement through soil water. Long distance spread is principally in soil on the roots of transplanted plants. These need not be susceptible species. Ability of the fungus to persist in the soil is unknown.

Urgency of the Problem

1. These Phytophthora species constitute a menace to the Port Orford white cedar stands and sites of Southwestern Oregon. Similarly, P. cinnamomi is a potential threat to

Douglas fir and other conifers in the Northwest. Torgeson (24) found 13 of 14 different isolates from 9 different hosts in 5 different states and Hawaii pathogenic to 2-1 Douglas fir seedlings in greenhouse tests at Corvallis. Ninety-two per cent of the firs were killed. These experiments confirm the reports of Urquijo (26) and Crandall and associates, of the pathogenicity to Douglas fir. Crandall's (11) statement is significant. "The disease is not known or has not yet been reported in nature on Douglas fir in the United States. The writer has viewed with some alarm the greenhouse demonstration of the high degree of susceptibility of Douglas fir Pseudotsuga taxifolia (Poir.) Britton to P. cinnamomi. This concern now seems justified by Pimentel's report (20) of the natural occurrence of the disease in plantings in Portugal."

2. It appears from the wide distribution of P. cinnamomi in the chestnut stands of Europe and from its production of the littleleaf disease on some 33,329 square miles of Piedmont short leaf pine (1) that the fungus is well suited to survival and spread under natural forest conditions.

Research Needs

Questions Requiring Prompt Research Attention

1. Acclimation of the fungus to the forest habitat and spread through forest soils of this region. If the fungus is introduced into a forest site, how long will it survive, at what rate will it spread and what damage will it do? What will be the influence of soil type, site condition, and stand condition on these factors:

2. How susceptible are the commercial conifers of the region? Are there available suitable resistant species to restock areas in which Douglas fir or white cedar may be destroyed? What are the influences of tree age on susceptibility?

3. What is the distribution of the fungus and are there means of restricting spread?

Problems of Less Immediate Concern Include the Following

1. Investigation of the possibilities of direct control in limited infections.

2. Investigation of the origin of P. lateralis and the ecologic relationships to distribution of Port Orford cedar.

General Recommendations

1. It is generally agreed that a close record should be kept of the overall occurrence and spread of the fungi. A general survey is not recommended but careful survey of areas particularly threatened appears essential. Survey of forest lands should be correlated with the work of the State Department of Agriculture, Oregon Agricultural Experiment Station, and Western Washington Experiment Station.

Close supervision of the forest nurseries of the region is essential. Receipt and planting of any rooted plants at forest nurseries should not occur. Extreme care should be exercised to procure leaf molds and composting materials from disease-free sources. A systematic program of testing for infection should be established. Stock to be used for forest planting should be obtained only from nurseries known to be free of these root rot diseases.

NEEDLE BLIGHT OF PONDEROSA PINE

Research to Date

A. The San Francisco branch of the Division of Forest Pathology (14) has worked on factors affecting infection, and on development and extent of the fungus within the host. Serious errors have been found in the only previous investigation of this disease (28). Recent studies have yielded useful information, but have been too limited in extent to supply definite answere to most of our questions.

B. A few plots have been established by the Portland branch of the Division of Forest Pathology to determine the effect of different intensities of infection on trees of various Keen classes. Final results will not be available for several years. Results thus far simply confirm what has become evident from general observation: that rapid killing of large volumes of timber occurs only under conditions extremely favorable to infection, and that mortality in most centers of heavy infection will occur more slowly, as low-risk trees are converted to high-risk through destruction of part of their crowns by the blight and as these high-risk trees subsequently fall prey to beetles and other enemies. The scope of the existing studies is too limited.

Urgency of the Problem

This disease fluctuates greatly. Twenty years ago, it was rare in many of the localities where it is now abundant. An over-extensive research program might result in waste of money if the disease should die down, as it has in the past,

before studies could be completed. On the other hand, real damage is being caused, and the present outbreak may become more severed. Other outbreaks will occur in the future, and the disease will cause damage until we learn to control it.

On the basis of our present limited knowledge, we can do little except salvage dead and dying timber, and possibilities of salvage are determined very largely by economic accessibility. Definite information on the conditions under which infection occurs, on the length of life of a given infection within the host, and on the rate of mortality under different severities of infection, would help in making salvage plans further in advance and in making cutting intensities conform more closely to the needs of a given situation. Accessibility will be greater during future outbreaks, but considerable information will still be necessary for efficient salvage, and much more will have to be known before control will become possible.

On the basis of the damage caused, and our deficient knowledge of disease development, the problem should receive more attention. Basic studies, especially of conditions governing infection, should be accelerated by appropriate agencies, and additional plots for mortality study should be established by the Portland branch of Forest Pathology. This work should be extended to include the effect of the disease on tree reproduction. Preliminary study of possible biological controls might be profitable.

Administrators of infested stands are in a position to add to knowledge of the habits of the disease. With technical

assistance when needed, administrators should make permanent records of dates when infection first becomes noticeable, extent and rate of increase or decrease, rate and character of damage, and miscellaneous items of possible significance, in each area of infection. Such records will be directly useful to managers of these stands during future outbreaks, will shed light on environmental factors associated with the disease, and will provide a mine of material when exhaustive studies finally become possible. Much useful information about needle blight can be obtained without technical aid, through careful observation over a period of years.

WHITE PINE BLISTER RUST

Research to Date

White pine blister rust is caused by a fungus that grows alternately on five-needle pines and currant and gooseberry plants commonly known as ribes (23). It kills white pines but is relatively harmless to ribes. Control is accomplished by destroying ribes from the immediate vicinity of the pine. Blister rust was unknowingly introduced to North America from Europe about 50 years ago and is now epidemic in nearly all parts of the United States where white pines grow. Significant losses of western white and sugar pines have already occurred in the Pacific Coast States (16). Pathologists and foresters in Europe, Canada, and the United States have already learned and published a great deal on how the rust lives and spreads and how to control it economically in white pine forests (15, 27). Much of this research, however, relates to pine and ribes hosts

other than sugar pine and its associated ribes in southern Oregon and northern California. For the Western States, knowledge of rust behavior has been adequate during the initial phases of the control program when the primary job was to reduce large populations of ribes to relatively safe levels. Now, however, control work in many sugar pine and western white pine areas has reached the stage where considerable savings could be made in ribes clean-up and maintenance if the rust-spread from ribes to pine, and the probability of pine infection in various sites and under specified climatic conditions, could be consistently and reliably predicted.

Urgency of Problem

In recent years experience of rust behavior in sugar pine and western white pine areas of the Western States shows that pine losses are markedly affected by the widely varying environmental conditions that exist in these areas. It is now recognized that further research is needed to fill gaps in our knowledge of how the rust develops and spreads in the specific forest tracts that have been selected for protection and management (19). This need is especially acute in the case of sugar pine forests of southern Oregon and California, because research was curtailed about the time that the rust was becoming widely distributed in these States. No research is being done at present on rust behavior in sugar pine types. The Blister Rust Control Office is attempting to bridge this gap by field studies on the status of control and the reliability of control standards.

Questions Needing Prompt Research

1. How do temperature, moisture, and light affect the viability and longevity of blister rust spores under conditions of the sugar pine-ribes association?

2. Can variations in microclimate be determined simply and accurately enough in the field to be useful in prescribing local rust hazard and needs for ribes suppression?

3. Can radioactive spores or simulated colored, fluorescent, radioactive, or chemically treated dusts and smokes be used to approximate movement and rate of fall-out of blister rust spores under different climatic and topographic conditions?

Other research and control problems have been specified in reports by the Blister Rust Control Office.

General Recommendations

It is suggested that Federal, State, and industrial agencies who are responsible for management and protection of white pine land, or who are able to assist with funds, technical facilities, and personnel, review the research needs on the blister rust problem, prepare work plans for high priority research, and indicate the participating agencies and their contributions.

FOREST NURSERY DISEASES

The forest nursery is a comparatively small operation upon which the entire planting program is dependent. A nursery disease loss which may be relatively small in dollar value may result in disrupting the planting program in the forest, thus causing a major economic loss.

The fact that the nursery may act as an infection source for the plantation, and may threaten the health of areas surrounding plantations through disease transmission in the planting stock, are further considerations arguing for effective disease control in the nursery.

The Division of Forest Pathology is now spending approximately four man-months a year on diseases in forest nurseries. If a planting program were undertaken commensurate with the area needing reforestation, the full-time of one pathologist should be devoted to nursery work.

DISEASES NEEDING PROMPT INVESTIGATION

MISTLETOE OF PONDEROSA PINE

Research to Date

Very little work has been done in this region on Arceuthobium campylopodum Engelm. on ponderosa pine. The most notable study is Weir's (29) early work on damage caused by the parasite. The Portland office of the Division of Forest Pathology has recorded observations on spread and distribution, and Dr. Lewis Roth (21) has presented quantitative data on these aspects of parasitic development.

Much information, basic as well as applied, is available for dwarf mistletoe in the southwest; however, these findings are to be applied to our problems with reservation inasmuch as different species of the parasite are involved and silvicultural and climatic features differ greatly between the two regions.

Urgency of the Problem

It is common knowledge among foresters and timber operators of the ponderosa pine region that dwarf mistletoe is widespread. In some localities, infestations are so intense that severe reduction in growth becomes general among the infected individuals and death is not uncommon. Where infestations are less intense, growth is retarded, but this loss, though it may be great, is usually not conspicuous. Reduction in lumber quality and in reproductive ability are reported in the literature (4).

Roth is of the opinion that in the Pringle Falls area growth and quality are reduced and a significant amount of direct killing is occurring. Differences in individual host response to infection are conspicuous. In local areas of heavy infection there appears little prospect of ever developing productive stands so long as present trees of either the overstory or understory occupy the site.

It has been stated (4) that mistletoe prolongs the period to maturity and lengthens the rotation. Recent observations suggest that on the contrary the period to maturity may not be prolonged but rather the decadence of over-maturity sets in earlier on mistletoe-infested trees, and a stand of full rotation value is never attained. Coupled with this observation is that of Childs, who believes that site may be under-rated because of mistletoe damage, rather than the opposite--that mistletoe is prevalent because of poor site quality.

The part that fire has played in restricting mistletoe in the Pringle Falls area (21) is so apparent that the conclusion that effective fire control will result in increased mistletoe damage appears well founded. In the pine region, over the long pull, mistletoe is the most important disease. "East-side" workers consider it a major cause for concern. The fact that mistletoe losses in this region have been neglected for 30 years is no excuse for further neglect.

Phases Requiring Research Attention

The most important consideration at present appears to be determination of actual damage. Because of the complex of factors affecting tree growth and stand development in the pine forest, measurement of damage is complicated. Nevertheless, it is very important. Knowledge of actual mistletoe losses is basic to establishing the need for control, in determining the pattern for control research, and in determining expenditures necessary or allowable for research and for control. A realistic picture of actual losses should be of immediate practical value to management and utilization planning.

Also needing investigation is the matter of method and rate of mistletoe spread through uniform stands, especially those in the younger age classes. This item assumes added importance with increased consideration of unit area pine management.

Exploitation of apparent heritable resistance is desirable as is investigation of the possibilities of control by chemical means.

DECAY IN SECOND GROWTH STANDS OF IMPORTANT TIMBER SPECIES

The great emphasis placed on decay in old growth timber has detracted from our understanding of these troubles in young growth. The impression has been created that decay is unique to over mature timber, and that it will no longer be a problem when management is based on a short rotation. While this assumption will undoubtedly hold with some fungi, it will not be true for all.

Some work on this problem with respect to Fomes pini is in progress by the Division of Forest Pathology and by the State Board of Forestry. Preliminary work on western hemlock has also been initiated by the Division of Forest Pathology. Preliminary observations on top rot are in progress at Oregon State College Department of Botany and Plant Pathology. Emphasis has been on extent of decay associated with various external indicators, selection of "crop" trees, damage by decay spreading from tree to tree through the roots, and management of stands top-rotted as a result of breakage.

Because of the highly irregular distribution of decay in second growth Douglas fir, case studies of numerous selected stands are needed. Information of the effect of various stand features on occurrence of top damage is needed. Especially needed in the field of decay is better information on factors regulating infection and the rate of decay.

ROOT AND BUTT ROT OF WESTERN HEMLOCK, PONDEROSA PINE AND OTHER IMPORTANT COMMERCIAL SPECIES

If experience in this region follows that in Europe and the eastern United States, an increase in root troubles may

be expected as management becomes more intense and rotations are shortened. Western hemlock and ponderosa pine are particularly liable to root rot. Fomes annosus (Fr.) Cke. and Armillaria melles (Vahl.) Quel. are commonly associated with the trouble.

Information is needed on distribution factors affecting occurrence and rate of spread. The relationship between root rot and bark beetle attack needs investigation. E. E. Hubert has made worthwhile contributions to our knowledge of these problems.

IMPORTANT DISEASES WHERE ATTENTION IS LESS URGENT

MISTLETOE ON WESTERN HEMLOCK, DOUGLAS FIR AND LARCH

Mistletoe is prevalent and destructive in important parts of the ranges of these species. It reduces both quantity and quality of wood produced, provides avenues of infection for heart-rotting fungi and weakens trees so that they are more easily killed by other enemies. Information is needed on rate and distance of spread, rate of intensification, and detection and propagation of resistant trees.

DISEASES IN FOREST PLANTATIONS

The disease history of forest plantations has been one of extreme liability to infection and to loss through physiological decline of the planted trees. Practically nothing is known of the disease situation in plantations of native species in this region. Since great areas must be planted, it is evident that intensive investigations should be made of the diseases and conditions that reduce survival and growth of planted trees.

ASSESSMENT OF PRESENT RESEARCH EFFORT

As has been pointed out in the first pages of this report, significant research in the pathology of living trees of this region is largely restricted to the Division of Forest Pathology of the Bureau of Plant Industry, Soils and Agricultural Engineering, with some small contribution by the State Board of Forestry, Oregon State College, and the Pacific Northwest Forest and Range Experiment Station.

The research effort of from four to five man-years annually is spread over a commercial forest area of 53,900,000 acres in the two states of Oregon and Washington, which area includes over 40 per cent of the nation's sawtimber supply, more than 630 billion board feet (12). Figuring on the basis of five men, each individual man-year is thus devoted to study of the diseases on eleven million acres of forest land, representing a volume of 126 billion board feet.

By contrast, research in the pathology of farm crops amounts to 14½ man-years in Oregon alone, where a total of 5,537,000 acres is in cropland. The fact that agricultural interests have succeeded in obtaining funds and manpower for such research efforts as these does not indicate that their problems are receiving unwarranted attention; it simply serves to emphasize the deficiencies in forest disease research.

If we appraise the present worth of the sawtimber stands of Oregon and Washington at $10 per thousand board feet, we find that the total value is $6.3 billions. At

least 60 per cent of the economy of the two states is founded on its forest lands and the industries dependent upon them. Yet we have only the most vague conception of the amount of damage caused by disease and even less information as to the counter measures which will best serve to reduce losses.

To be fully useful, research in any of the biological sciences should progress far in advance of field application. In the case of forest pathology, research has lagged far behind. We cannot expect that the application of intensive forest management to the timberlands of this region will reduce disease losses, unless research provides the working tools needed to keep these losses at a tolerable minimum. On the contrary, intensive management may be expected to increase the losses, if the pattern found in the eastern United States and in Europe serves as a guide to what can reasonably be expected (13).

The questions of the amount and allocation of research funds which should be raised, and the securing of pathologists and facilities, are beyond resolution by this committee. However, it is apparent that the need should be met in proportion to the values at stake in securing the full productivity of our forest land, and in protecting the existing timber crop. Any effort we can make will not be in excess of the need.

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